BA Writers Guidance for Preparing the Stormwater Section of Biological Assessments

Revised September 20, 2006

This joint Federal Highways Administration (FHWA) and Washington State Department of Transportation (WSDOT) approach consists of grouping projects into three levels of consultation analysis effort depending on the potential effects of the stormwater runoff associated with the project.

Projects that will not have stormwater effects on listed species or proposed or designated critical habitat due to location, absence of the species and habitats, or a project type that does not have new impervious surface and does not alter flow conditions (e.g., bridge seismic retrofit, ACP overlay, guardrail installation, etc.) are not subject to this guidance. These projects are expected to include a stormwater discussion as part of the project description and to document the lack of effects on listed species in the effects analysis.

- Level One analysis is for projects that will result in no net increase in pollutant loading and will not alter flow (base flow, peak flow, or duration).
- Level Two analysis is for projects that may result in some small increase in pollutant loading and/or flow alteration, but does not result in a net increase in pollutant concentrations.
- Level Three analysis is for projects that may result in a moderate increase in pollutant loading or pollutant concentrations, and/or moderate alterations to flow.

The purpose of grouping projects by their potential stormwater effects is to establish the level of analysis necessary to complete Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultation. The informational needs addressed in each level focus on the associated stormwater assessment methodology. Standard baseline information on existing conditions, including information on water quality and effects of the project are to be included in the project's Biological Assessment (BA) and are not identified as information needs in this guidance. The amount of detail included in the baseline information should be commensurate with the project impacts. If it exists, representative site-specific baseline information must be used. The pre-BA meeting is a good time to start this discussion with the Services in terms of what information to use to characterize baseline. This stormwater guidance will be updated as needed and will be available on the WSDOT Environmental website on the Fish and Wildlife page. All BA's must include the rationale as to how you are using this guidance in preparing the BA and a reference to the version/date of this guidance used in preparation of the BA.

Level One Stormwater Analysis

Criteria: Projects that will result in no net increase in pollutant loading and will not alter flow (base flow, peak flow, or duration).

Examples of Projects that May Result in No Net Increase of Pollutants Include:

- Projects that remove at a minimum an equivalent or greater amount of existing impervious surface than is created (i.e. no net increase in impervious surface pre- and post-project); and/or

- Projects that treat existing impervious surface (i.e. retrofit) in addition to the impervious surface that is created (resulting in a net balance or reduction of pollutant loading).

Note: Removing a low-load producing surface to compensate for a high-load producing surface may not result in a no-net increase of pollutants.

Examples of Projects that May Result in No Effect on Flow in Receiving Waters Include:

- Projects designed in accordance with the requirements of the HRM (for new impervious surface) that:

  - ☐ Infiltrate all runoff; and/or

  - ☐ Discharge to flow control exempt waterbodies. The list of Ecology approved flow control exempt waterbodies is located in section 3-3.6.2 of the Highway Runoff Manual (HRM) – page 102 of 604

    http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/HighwayRunoffManual.pdf

    The USFWS considers there will be no effect to flow only for the following waterbodies: Puget Sound; Columbia River; and Lakes Sammamish, Silver, Union, Washington and Whatcom. NOAA considers there will be no effect to flow only for the following waterbodies: Puget Sound, Columbia River, and Lake Washington, and only when water is not transferred from contributing watersheds with ESA or EFH resources. Discharges to any HRM exempt waterbody not on the USFWS and/or NOAA list requires providing in the BA the rationale as to why there is no effect on flow; and/or

  - ☐ Disperse all runoff, without discharging runoff either directly or indirectly through a conveyance system to surface waters; and/or

- ◻ Replace lost hydrological functions by restoring upland, wetland, riparian and/or floodplain habitats within the affected watershed(s). This concept will require some work with the Services and Ecology before it can be used.

BA Content

Performance Standards to be Included in the BA:

1. The project will result in no net increase in pollutant loading.

2. The project will not adversely impact existing base flows. (Note that infiltration may help maintain base flows)

3. Project-generated runoff will not result in stream channel erosion rates greater than those characteristic of pre-project conditions. (Note that the project may decrease erosion rates)

Effects Analysis:

- Focus on the effects of construction activities and location of stormwater BMPs.

- Include description of net-new impervious surface area, what BMP treatment methods may be used, especially flow control (i.e., infiltration and dispersion), and how the project's net-new impervious surface area meets the Level One criteria. Since the pollutants of concern are dissolved metals, the project may include retrofit of existing untreated impervious surface such that the project will result in no net increase in metals loading to any receiving waters and watersheds that contain listed fish or designated critical habitat.

- Use the following calculation, and information provided in Table 1 below, to determine and compare the pre- and post-project pollutant loading for each pollutant category (i.e., total suspended solids (TSS), total copper, total zinc, dissolved copper, and dissolved zinc).

  To calculate the effluent pollutant load pre-project:

  Multiply the acres of existing untreated impervious surface by the loading figures from the "Untreated Runoff" column in Table 1 below. Add the acres of existing treated impervious surface that discharge to a surface waterbody multiplied by the loading figures from the "Treated Runoff" column. You should exclude existing impervious surface where runoff is infiltrated since it does not discharge to a surface waterbody.

Table1. Annual Pollutant Loads from Untreated and Treated Pollution Generating Highway Surfaces (source, 2005 WSDOT NPDES Progress Report)

Pollutant	Untreated Runoff (lbs/acre/year)	Treated Runoff (lbs/acre/year)
Total Suspended Solids (TSS)	565	45
Total Zinc	1.1	0.28
Dissolved Zinc	0.4	0.2
Total Copper	0.2	0.065
Dissolved Copper	0.053	0.035

To calculate the effluent pollutant load post-project:

Multiply the total acres of untreated impervious surface by the loading figures from the " Untreated Runoff" column in Table 1 above. Add the acres of treated impervious surface that discharge to a surface waterbody multiplied by the loading figures from the "Treated Runoff" column. You should exclude existing and new impervious where runoff is infiltrated since it does not discharge to a surface waterbody.

To calculate pollutant load reduction achieved from runoff treatment:

Subtract the post-project load from the pre-project load. A negative number means a net pollutant load reduction.

If the project cannot show a net decrease in pollutant loading, the Level Two analysis is required.

Example Calculation

Project with 4 acres of existing impervious surface, 1 acre of which is currently infiltrated, 1 acre is treated and discharged to a surface waterbody, and 2 acres are untreated. The project will retrofit 1 acre of existing impervious and add 1.5 acres of new impervious, all of which will be treated prior to discharge into a waterbody. Treatment is consistent with HRM 'enhanced' treatment.

The pre-project pollutant load TSS is:

(2 acres untreated * 565 lbs/acre/yr) + (1 acre treated * 45 lbs/acre/yr) = 1175 lbs./year

The post-project pollutant load for TSS is:

(1 acre untreated * 565 lbs/acre/yr) + (3.5 acres treated * 45 lbs/acre/yr) = 722.5 lbs./year

The pollutant load reduction for TSS is:

722.5 lbs – 1175 lbs = -452.5 lbs./year

While this example has a net load reduction for TSS, total copper, and total zinc, both dissolved copper and dissolved zinc would show a slight load increase. Therefore, this project must go on to Level 2 analysis.

WSDOT and FHWA will develop performance standard language regarding maintaining or reducing pollutant-load levels in receiving waters and maintaining or enhancing base flows.

Level Two Stormwater Analysis

This level includes projects that do not meet the criteria associated with Level One consultations due to project-specific circumstances. These circumstances can include location, amount of net-new impervious surface created, retrofit levels, treatment levels, baseline conditions of the receiving waterbody, and/or presence or absence of species/habitats or effects.

Criteria: Projects that may result in some small increase in pollutant loading and/or flow alteration (base flow, peak flow, or duration), but does not result in a net increase in pollutant concentrations.

Examples of Project Types that may be Appropriate for Level Two Analysis Include:

- Projects that do not achieve no net-increase in pollutant loading.
- Projects able to meet the no net-increase in pollutant loading, but are unable to fully attenuate flow by discharging to a flow control exempt waterbody, or by providing for complete infiltration or dispersion.
- Projects discharging stormwater runoff to receiving waters where listed species/habitats are not likely to be present and/or effected.
- Projects adding minimal impervious surface and discharging to waterbodies that are properly functioning. The rationale supporting a Level Two analysis must be included in the BA.

BA Content

The analysis will utilize existing data and will focus on potential project effects to general aquatic habitat. It will focus on net-new acres of impervious surface and stormwater treatment levels. The BA will address the effects of the project on the baseline of the receiving waters.

Project Description and Baseline Information for Stormwater[1]:

1. Determine the baseline (pre-project) runoff treatment and flow control. Using existing information obtained from the HRM's Endangered Species Act Stormwater Design checklist (ESA checklist) provided by the Project Office, determine:

   a. How much impervious surface is in the project area (note that this information may be provided on a threshold discharge area basis)?

   b. How are existing impervious surfaces being treated, what BMPs are in place, if any?

   c. Describe where the discharge points are located and, if applicable, the receiving waterbody. For discharges to waterbodies, determine if the receiving water is on the HRM's flow control exempt list. If the discharge is to a HRM exempt waterbody not on the USFWS or NOAA list of acceptable exempt waterbodies (see page 2), provide rationale as to why the flow effects are minor.

   d. Characterize the existing pollutants of concern. Currently the Services have requested that the following be analyzed:

      - Total suspended solids (TSS).

      - Copper. Copper is usually analyzed or reported as total copper, but the dissolved portion is what is of concern to the Services – the particulate part tends to settle out and is not considered bio-available.

      - Zinc. Zinc is usually analyzed or reported as total zinc, but the dissolved portion is what is of concern to the Services – the particulate part tends to settle out and is not considered bio-available.

[1] Note the additional baseline information provided by the ESA checklist, in addition to information about species and habitats present in the action area are to be included in the BA along with a complete description of the project effects including clearing, grading and new impervious surface, etc.

- Lead. Lead levels have dropped greatly since the introduction of unleaded gasoline.

- Cadmium. Cadmium is also reported as solid or dissolved and is often not detected in highway runoff.

- Chromium and Polycyclic Aromatic Hydrocarbons (PAHs), are solids and are expected to be removed through the removal of TSSs.

Information on other pollutants normally found in highway runoff can be found in Exhibit 6-1 of WSDOT's 2005 NPDES Progress Report for the Cedar-Green, Island-Snohomish, and Southern Puget Sound Water Quality Management Areas (NPDES Progress Report, September 2005). Several annual monitoring reports are available at:

http://www.wsdot.wa.gov/Environment/waterquality/#NPDES

WSDOT has monitored for lead, chromium, and cadmium in the past and has generally not found these pollutants in untreated stormwater runoff at levels high enough to detect. Current monitoring and data collection completed by WSDOT does not include sampling for these metals.

The Services are also requesting information on PAHs. WSDOT has not monitored for PAHs in Washington State. Caltrans has monitored and found that PAHs are rarely detected in untreated runoff and when detected are at levels below current standards (Stein, 2006). However, detection ability depends on the lab method used; therefore detection failures are relevant only in the context of the detection limit. PAH toxicity has been observed at low concentrations. Sediment contaminated with PAHs at levels toxic to aquatic life have been attributed to stormwater discharge. As new information emerges, we will reevaluate information needs in this section.

Based on this information the following standard language should be placed in each BA concerning lead, chromium, cadmium and PAHs. Additional background information can be found in Appendix A. Include this appendix material as an appendix to BA's.

Summary of Risk from Cadmium, Lead, Chromium, and PAH Compounds in Stormwater Associated with WSDOT projects.

Stormwater associated with highway runoff may contain low levels of cadmium, lead, chromium, and PAH compounds. Often, these compounds are *at or below levels that can be detected with current analytical methods and may be effectively filtered or settled out in stormwater BMPs prior to being discharged to nearby waterbodies. Based on the environmental chemistry and biological fate of these compounds in an aquatic system, exposure to ESA-listed species is expected to be small.*

e. Identify if your project is at Moderate or High Risk of producing runoff with high pollutant concentrations that could impact streams or lakes. "Moderate risk" highway projects pose a moderate risk of producing runoff with low-moderate concentrations of pollutants. Projects are "moderate risk" is they have an average daily traffic (ADT) less than 60,000. Average effluent concentrations for treated WSDOT runoff are used to represent the expected pollutant concentration for projects in this category.

   "High Risk" highway projects pose a high risk of producing runoff with high concentrations of pollutants. Projects in the high-risk category have traffic levels exceeding 60,000 ADT, and have completely closed conveyance systems (no opportunity for infiltration or passive treatment in vegetation). The 90th percentile effluent concentrations for treated WSDOT runoff are used to represent the expected concentrations for projects in this category.

f. Use Table 2 below to identify the expected effluent concentration by pollutant that would likely be generated before and after the proposed action. These numbers developed using data collected from a range of BMPs currently in use by WSDOT. The data in Table 2 are indicative of expected situations. Use the appropriate 'moderate' or 'high-risk' column depending on the criteria in Section 1.e above.

Table 2. Expected Pollutant Concentrations for Untreated and Treated Runoff (source, 2005 WSDOT NPDES Progress Report)

Pollutant	Untreated Runoff		Treated Runoff	
	Moderate Risk	High Risk	Moderate Risk	High Risk
Total Suspended Solids (mg/L)	93	192	6.4	14
Total Copper (ug/L)	31	59	7	12
Dissolved Copper (ug/L)	7.6	14	5	7.8
Total Zinc (ug/L)	174	350	40	67
Dissolved Zinc (ug/L)	62	110	27	44.8

To calculate effluent concentration pre-project:

- Multiply acres of untreated impervious surface by the expected pollutant concentrations in untreated runoff (Table 2 above). Use the moderate or high-risk column as determined previously.
- Add the acres of existing treated impervious with discharge to a waterbody multiplied by the expected pollutant concentration in treated runoff.
- Divide the sum by the total acres of pre-project existing treated and untreated impervious surface to determine expected concentrations.
- Calculation must be done for each pollutant of concern

To calculate effluent pollutant concentrations post-project:

- Multiply acres of untreated impervious surface by the expected pollutant concentrations in untreated runoff (Table 2 above). Use the moderate or high-risk column as determined above.
- Add the acres of existing treated after the project multiplied by the expected pollutant concentration in treated runoff.
- Divide the sum by the total acres of treated and untreated impervious surface to determine expected concentrations.
- Calculation must be done for each pollutant of concern.

Example Calculation

Project with 4 acres of existing impervious surface, 1 acre of which is currently infiltrated, 1 acre is treated and discharged to a surface waterbody, and 2 acres are untreated. The project will retrofit 1 acre of existing impervious and add 1.5 acres of new impervious, all of which will be treated prior to discharge into a waterbody. Treatment is consistent with HRM 'enhanced' treatment. ADT is 30,000 (moderate risk).

The pre-project pollutant concentration for TSS is:

(2 acres untreated * 93 mg/l) + (1 acre treated * 6.4 mg/l) / 3 acres = 64.13 mg/l

The post-project pollutant concentration for TSS is:

(1 acre untreated * 93 mg/l) + (3.5 acres treated * 6.4 mg/l) / 4.5 acres = 25.64 mg/l

The pollutant concentration reduction for TSS is:

25.64 mg/l - 64.13 mg/l = -38.49 mg/l

This example has a net concentration reduction for TSS as well as total copper, total zinc, dissolved copper, and dissolved zinc (not shown).

g. To the extent possible with available data, determine the baseline conditions of the receiving waterbodies.

- This step may already be completed as part of the baseline evaluation of waterbodies in the action area.

- Gather available information on receiving waterbodies' size/volume, flow rate, chemistry (e.g., hardness) and background concentrations of pollutants of concern relative to the runoff discharge volume and pollutant concentrations. If available, information on benthic invertebrate communities can be included.

- Gather information on other potential stressors such as temperature, other potential pollutants such as pesticides, dissolved oxygen, etc.

- This data may not be available for most waterbodies of interest. If there is no data available, you will not be able to document the baseline in the receiving body.

h. Many data sources are available. When selecting data sources, strive to utilize data that has been quality controlled. Potential information sources include:

- Department of Ecology (DOE) 303(d) list;

- The Limiting Factors Analysis by Washington State Conservation Commission;

- Local agencies;

- USGS Annual Washington State Data Report for water year 2005 (http://wa.water.usgs.gov/data);

- Additional water quality information may be available from the Environmental Protection Agency and the United States Geological Survey.

Effects Analysis:

1. Compare baseline information to post-project information using information obtained from the Project Office (information in the ESA stormwater checklist), and the baseline information gathered for the BA. Determine:

    a. The total amount of net-new pollution generating impervious surface created in the project area;

    b. The amount of existing pollution-generating impervious surface that will be retrofitted in the project area; and

    c. Describe what runoff treatment BMPs are anticipated for use on the project.

2. Identify the receiving waterbodies and determine how much runoff may be discharged to each:

    a. Use the ESA Stormwater checklist to identify how much net-new impervious surface will be created by the project. Use this information to determine the flows that may be generated by the project. Also, describe the level of runoff treatment and flow control employed. Some projects may result in no net-increase of pollution generating surfaces. Other projects may be using 100% infiltration.

    b. Determine under what conditions, if any, a storm event will result in a discharge to a receiving water. This will be the design storm for runoff treatment BMPs employed, either flow-based and/or volume based (e.g., wetpools and infiltration facilities). Infiltration BMPs will not result in a direct discharge to any receiving waters unless an extreme storm event (i.e., one that exceeds the design storm) overwhelms the system.

       Design storm criteria for sizing runoff treatment facilities exist in the HRM. The “Water Quality Design Storm” is defined in the HRM in terms of recurrence interval. All of the runoff treatment BMPS are designed to treat specific water quality design storms. Water Quality Design Storms are different for eastern and western WA, and also vary depending on BMP type (flow-based vs. volume-based BMPs).

c. Determine which receiving bodies, if any, may be receiving stormwater discharge.

3. Evaluate the effect of the stormwater on the baseline conditions of the receiving waterbodies.

   a. In a general manner, assess how stormwater discharge affects the receiving water baseline.

      - Compare the expected effluent concentration from the project to the pre-project effluent concentration as determined in Section 1.f. above (page 8). Use this information to determine if the project potentially results in lower or higher concentrations of pollutants entering the receiving body.

      - If a project is retrofitting to provide treatment to existing untreated impervious surface, the project may actually result in a net improvement of the baseline water quality, thus decreasing the exposure to the fish and the risk to the species.

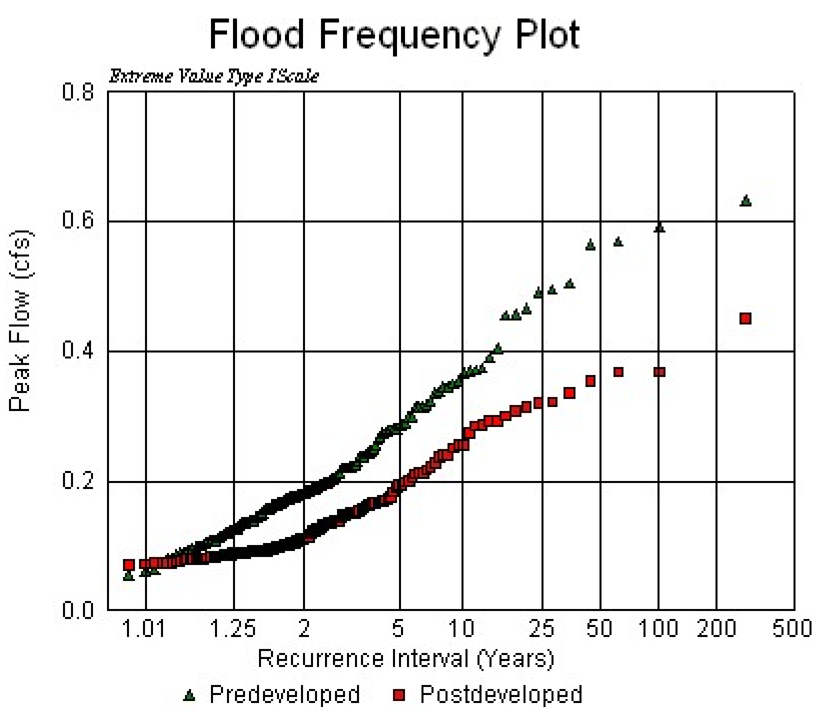
      - Compare the post-project annual pollutant loads to the pre-project pollutant loads as was developed in Level 1 effect analysis (pages 3-4). If the project results in a net-increase in pollutant load, then the fish may face an increased exposure to the pollutants. Exposure will depend on species presence, amount and location of discharge to the receiving water and the assimilation capacity of those receiving waters. It is important to recognize that that not all storm events will result in a discharge to receiving waters.

   b. Evaluate the effect of the BMPs on peak flow, flow durations, in-stream base flows, and the potential for in-channel effects such as scour or down-cutting. Flow control is intended to minimize erosive flows in the channel and thus reduce adverse impacts to fish from channel erosion (e.g., increased turbidity, down-cutting, washing away or covering spawning gravels, etc.). Sources for this information will include the ESA Stormwater Checklist, hydrology or water resources discipline reports, or outputs from MGSFlood or similar software.

      - Generally speaking, BMPs that detain and discharge runoff to receiving waterbodies will not maintain or contribute to in-stream base flows to the same degree as BMPs that infiltrate runoff or retain runoff. However, depending on the nature of the receiving water and/or baseline land conditions in the basin, and the position of the project in the watershed, this may not necessarily result in an adverse effect (e.g., direct discharges to flow control exempt waterbodies, projects located in floodplains above high seasonal groundwater or bedrock, etc.). In most instances where projects discharge to tidal waters, daily runoff will have minimal effect on flow compared to tidal exchange. Also, in cases where all project stormwater is being treated by infiltration, impacts to flow will be minimal or nonexistent.

- BMPs that discharge runoff into dispersion areas, "leaky runoff treatment BMPs" (e.g., ecology embankments, swales, vegetative filter strips, constructed treatment wetlands, wet ponds, etc.) and infiltration systems (e.g., infiltration ponds, trenches, and vaults), will help maintain the natural hydrology.

- Detention-type BMPs (e.g., detention ponds and vaults), while mitigating adverse impacts from peak-flow, may significantly lengthen flow durations and/or reduce in-stream base flows. In such cases where flow control is proposed, output results from MGSFlood (or similar software) should be provided to document that flow duration and frequency will not be detrimentally affected by the proposed project. For example, the plot displayed below is generated by MGSFlood and documents that flood frequency under post-developed (i.e., with flow control) conditions will be less than under pre-developed (i.e., existing conditions).



- The relative size of the discharge to the size (volume) of the receiving water will help determine the extent, if any, to which stormwater flows effect the receiving waterbodies.

4. Determine what the effect of the stormwater is on listed species and habitats.

   a. Evaluate the listed species and habitats in the receiving waters –

      - What species are there?
      - What is the run timing?
      - How do the species use the system? (i.e. spawning, rearing, etc.)
      - What is the residual rate for Chinook?
      - Is it critical habitat? Which primary constituent elements of critical habitat are present?

      In other words, when are the fish likely to be there and in what life-stage form are they present at what time of year. The goal is to determine if the fish may be present when runoff discharge occurs. Effects to habitat can be permanent and the absence of listed species at the time of discharge may not be relevant in those cases.

   b. Using information regarding the potential changes to baseline conditions in the receiving waters and the presence or absence of listed fish, determine what effect the runoff discharge may have on fish. If there are no fish present at the time of the runoff discharge, there will be no direct effects to the species but may be to habitat. There may still be some indirect effects to species, but that will depend on whether prey species are potentially affected, and the time of year the effects may occur.

Level Three Stormwater Consultations

Projects that will result in moderate increases in pollutant loading, pollutant concentration, or unattenuated flows into natural systems are appropriate for Level Three consultations. These projects will typically create significant amounts of new impervious surface, create new roads, occur in watersheds with degraded baselines that support runs which are at risk, or discharge to waterbodies in which listed fish are present and have the potential to be exposed to the adverse effects of the runoff. The analysis for Level Three consultations will be very detailed.

Criteria: Projects that may result in a moderate increase in pollutant loading or pollutant concentrations, and/or moderate alterations to flow (base flow, peak flow, or duration).

BA Content

Project Description and Baseline Information:

Include the same information as described for the Level One and Two Analysis.

If the project is creating a new road, and thus there is no existing impervious surface, the information in Exhibit 431-4 of the Environmental Procedures Manual (EPM) should be used to determine what the current annual pollutant load is resulting from existing land uses (this will become the baseline stormwater condition to which project impacts will be compared). Note that the pollutants from untreated and treated runoff are reported as mean annual loads and may or may not be an accurate representation of the runoff from the project area – a caveat should be included.

Effects Analysis:

Include the same analysis as described for the Level One and Two Analysis. While the Level Two Analysis gets to general effects of the project on the baseline of the receiving water, and the potential effects to fish based upon pollutant concentration, this level of analysis goes a step further and attempts to quantify the exposure through dilution modeling. This level may also analyze effects at the threshold discharge area (TDA) basis rather than addressing runoff effects at a watershed- or project-level scale. The TDA-scale analysis may be useful if impacts may vary by receiving waterbodies (i.e., some receiving bodies may be impacted from the runoff discharge and others will not).

For some projects, such as projects creating new roads, the annual pollutant loading modeling completed in Level 1 and 2 analyses must identify the pollutant loads from existing land uses. See Method 2 in exhibit 431-4 of the Environmental Procedures Manual. When completing this pollutant loading modeling, load reductions due to infiltration via stormwater conveyances and "leaky" BMPs should be incorporated as appropriate. The input data for the model should be provided as supplemental information in an appendix to the BA.

Modeling for downstream effects such as modeling for the dilution of the stormwater effluent at the outfall in a receiving waterbody should be completed. Ecology's dilution model RIVPLUM5 is available: at:

http://www.ecy.wa.gov/programs/eap/mixzone/app6-1/pwspread.html

This model will provide information on how far the stormwater discharge plume would extend downstream from the outfall and what the dilution factor would be. Inputs for this model will need to be obtained from a variety of sources, including the BA, the ESA stormwater checklist, the MGSFlood outputs, and other resources Additional information can be obtained by using Ecology's Reasonable Potential Analysis (REASPOT.XLS) and LIMIT.XLS spreadsheets on Ecology's web site at:

http://www.ecy.wa.gov/programs/eap/mixzone/app6-1/pwspread.html

Ecology provides the spreadsheet to help NPDES permittees determine the potential for their discharges to cause water quality problems and to calculate effluent limits. On the web page, Ecology states: "*The spreadsheets REASPOT.XLS, and LIMIT.XLS determine reasonable potential (to violate the aquatic life water quality standards) and calculate effluent limits. The process and formulas for determining reasonable potential and effluent limits in these spreadsheets are taken directly from the Technical Support Document for Water Quality-based Toxics Control, (EPA 505/2-90-001).*"

Standards or criteria for effects on species/habitats following dilution modeling are not currently known. Best professional judgment and Best Available Science should be used in the project analysis to determine if a project that has a net increase in pollutant load and/or concentration at the point of concern is an adverse effect on listed species and/or habitats. The rationale for the determination must be included in the BA.

APPENDIX A

Cadmium (Cd)

Cadmium is a relatively rare, naturally occurring metal. Naturally, its initial route of entry to the environment is often via the atmosphere or through the weathering of rocks, soil and volcanoes. However, these sources are minor compared with anthropogenic sources. Anthropogenic sources associated with the transportation system include lubricants, automobile exhaust, tire wear, galvanized steel, and pesticides. Cadmium is found as Cd^{2+} in water (Callahan et al., 1979).

Cadmium particulates that settle on the roadway from automobiles and dry and wet atmospheric deposition will become part of stormwater runoff. According to past WSDOT NPDES reports and the International BMP Database (http://www.bmpdatabase.org/), cadmium is rarely detected in stormwater above analytical detection limits. Cadmium that is present in stormwater is found in very low concentrations.

Cadmium that becomes part of runoff is rapidly adsorbed onto particulate matter (Callahan et al., 1979) and will be filtered or settled out in appropriate types of BMPs, such as those BMPs that filter or settle out solids and uses organic material as a filter or "sink" (i.e. ponds, vegetated swales, ecology embankments). Adsorption increases with pH and the organic content of the soil. Therefore leaching is more apt to occur under acidic conditions in sandy soil (SRC, 1999). Cadmium may also precipitate as the carbonate or be adsorbed by or coprecipitate with hydrous iron, aluminum, and manganese oxides (SRC, 1999). Many plants have the ability to accumulate cadmium, primarily in the roots, but also in the stem and leaves (McCracken, 1987). Cadmium does not form volatile compounds in the aquatic environment (Callahan et al., 1979); therefore, volatilization from water is not a significant fate process.

Cadmium that is not removed in a BMP and enters surface water is rapidly adsorbed onto particulate matter and settles out. Studies have shown that cadmium concentrations in bed sediment are at least an order of magnitude higher than in the overlying water (Callahan et al., 1979). The uptake of cadmium by many aquatic invertebrates can be appreciable (McCracken, 1987). Cadmium is taken up in fish both from the water and in their diets. However, studies have shown that water is the primary source of uptake with diet playing a minor role (McCracken, 1987). In fish, the gill is a key site for metals uptake, but organs such as the liver and kidney can become susceptible as the contaminant is detoxified and eliminated (Riddell et al., 2005). Riddell et al (2005) determined in a study using an experimental aquatic food web, that exposures of 0.5ug/L Cd can have sublethal effects on brook trout (*S. fontinalis*), but also noted a species-specific cadmium tolerance between test species. Studies comparing the cadmium toxicity in bull trout to current

regulatory water quality standards have suggested that the recently revised US federal Aquatic Life Criteria value for the protection of aquatic biota will be protective of sensitive ESA-listed species (Hansen et al., 2002). The ALC values are a function of water chemistry and can be found at
http://www.epa.gov/waterscience/criteria/aqlife.html.

Lead (Pb)

Lead is the fifth most prevalent metal commercially in the United States. Anthropogenic sources associated with the transportation system include bridge paint, automobile exhaust, tire wear, lubricating oil & grease, and bearing wear. Pb^{2+} is the stable ionic species of lead and readily binds to organic compounds in the natural environment.

Lead particulates that settle on the roadway from automobiles will become part of stormwater runoff. According to past WSDOT NPDES reports and the International BMP Database (http://www.bmpdatabase.org/), lead is rarely detected in stormwater above analytical detection limits. Lead that is present in stormwater is found in very low concentrations.

Lead that becomes part of runoff is effectively removed from the water column to the sediment by adsorption to organic matter and clay minerals, precipitation as insoluble salt (carbonate, sulfate, or sulfide), and reaction with hydrous iron, aluminum, and manganese oxides (SRC, 1999b). Only a small fraction of lead in soil appears to be in water-soluble form (Khan, 1983). In soil, lead is relatively immobile and can persist for long periods of time (USEPA, 1979). The efficient fixation of lead by most soils greatly limits the transfer of lead to aquatic systems and also inhibits absorption of lead by plants (Kayser et al., 1982). Lead is tightly bound to most soils with virtually no leaching under most conditions (Zimdane and Hassett, 1977). Lead is most available from acidic sandy soils which contain little material capable of binding lead (NRCC, 1978). Due to its very low vapor pressure and insolubility, volatilization of lead from soil or water will be negligible (SRC, 1999b). BMPs that filter or settle out particulate matter will be effective at removing lead from the runoff (i.e. ponds, vegetated swales, etc.).

Lead that is not removed via BMPs and is introduced into the aquatic environment is associated with particulate matter that settles down into the sediments (Botelho, 1994). However, biomethylation of lead by benthic microorganisms can lead to its remobilization and reintroduction of lead into the aqueous environment (Schulz-Baldes, 1983). Cycling of lead in estuaries involves a complex exchange between dissolved and particulate phases (Elbaz-Poulichet, 1984). It has been demonstrated that Pb^0 and Pb^{2+} can be oxidatively methylated by naturally occurring compounds resulting in the dissolution of lead already bound to sediment or particulate matter (Craig and Rapsomanikis, 1985).

Aquatic biota, both invertebrate and vertebrate, have been shown to bioconcentrate lead at levels greater than are present in water and sometimes similar to those levels present in sediments. However, the concentration of lead tends to decrease with increasing trophic levels in aquatic systems (USEPA, 1979). Lead does not appear to bioconcentrate significantly in fish but does in some shellfish such as mussels (SRC, 1999b). Fish do not appear to accumulate lead as readily as the invertebrate species they may eat (Kayser, et al., 1982). Multiple studies (MacDonald et al., 2002; Schwartz et al., 2004) have shown that metal toxicity to aquatic species varies with water chemistry and other environmental factors.

Chromium (Cr)

Chromium is a widely distributed metal in the earth's crust, but is rare in unpolluted waters (SRC, 2002). Chromium's valence states range from Cr^{2-} to Cr^{6+}, but the important valence states of chromium are the trivalent state [Cr(III)] and the hexavalent state [Cr(VI)]. Chromium compounds are stable in the trivalent state and the hexavalent state is the second most stable state. Hexavalent chromium rarely occurs naturally, but is produced from anthropogenic sources. Chromium compounds are released into the atmosphere mainly by anthropogenic sources. Naturally occurring gaseous forms of chromium are rare (Carey, 1982). Anthropogenic sources associated with the transportation system include metal plating, moving engine parts, and brake lining wear, and via the combustion of natural gas and oil.

Chromium particulates that settle on the roadway from dry and wet atmospheric deposition will become part of stormwater runoff. The Caltrans runoff characterization study at (http://www.dot.ca.gov//hq/env/stormwater/special/newsetup/_pdfs/monitoring/CTSW-RT-03-065.pdf) indicates that chromium is a low monitoring priority because the estimated percent exceedence of untreated runoff with California standards is 0.01%.

Chromium will be as soluble and insoluble forms. Most of the soluble chromium is present as Cr(VI) but this generally accounts for only a few percent of the total (Carey, 1982). Chromium that becomes part of runoff is generally removed from the water column to the sediment by adsorption (Carey, 1982). BMPs that filter or settle out particulate matter may be effective at removing chromium from runoff (i.e. ponds, vegetated swales, etc.).

Adsorption of chromium to sediment varies with water chemistry, but Cr(III) tends to be the most prevalent in sediment; occurring mostly as suspended solids adsorbed onto clay material, organics, or iron oxide present in water (Carey, 1982). Adsorption of Cr(III) increases with pH (Bodek, 1988; Fukai, 1967). Cr(VI) is water soluble and a strong oxidant (Carey, 1982). In the Columbia River, dissolved Cr(III) generally accounts for only 3% of the dissolved chromium and Cr(VI) accounts for over 90% (added by atomic reactor cooling water) (Carey, 1982).

As pH decreases, adsorption of Cr(VI) to sediment increases (Saleh et al., 1989). Organic matter in soils reduces Cr(VI) to Cr(III) spontaneously. On the other hand, Cr(III) can oxidize to Cr(VI). However, oxidation of Cr(III) will not be significant in most natural waters because dissolved oxygen by itself in natural waters does not cause any measurable oxidation of Cr(III) to Cr(VI) (Saleh et al, 1989).

Based on the above information, most chromium compounds that are discharged into receiving waters will ultimately be deposited in sediments. Generally, there is little tendency for Cr(III) to accumulate along food chains (NRCC, 1976). Bottom-dwelling fish like, flounder are known to accumulate Cr(VI) (Calamari et al., 1982); however, chromium is not expected to biomagnify in the aquatic food chain (SRC, 2002).

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are organic substances made up of carbon and hydrogen atoms grouped into at least two condensed aromatic rings structures. These are divided into two categories: low molecular weight compounds composed of fewer than four rings and high molecular weight compounds of four or more rings. Anthropogenic sources associated with the transportation system include automobile exhaust, atmospheric deposition, and creosote-treated products.

PAHs that settle on the roadway from atmospheric deposition will become part of stormwater runoff. However, Caltrans concluded that tested PAHs were a low monitoring priority because they were either never detected, or had an estimated percent exceedence with California standards of <0.01% in untreated stormwater (http://www.dot.ca.gov//hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-01-050.pdf).

PAHs that become part of runoff are expected to adsorb to suspended solids and sediment. In general, PAHs with higher molecular weights are almost completely adsorbed onto fine particles and are expected to be immobile in soil. Lower molecular weight PAHs are partially adsorbed and are expected to have slight to no mobility in soil (ATSDR, 1995). BMPs that filter or settle out particulate matter may be effective at removing PAHs from the runoff (i.e. ponds, vegetated swales, etc.).

PAHs that are introduced to the aquatic environment via runoff are generally associated with sediment and may accumulate over time. In aquatic environments, low molecular weight PAHs generally biodegrade relatively rapidly (SRC). In soil, degradation of PAHs with 3 rings generally takes weeks to months and is primarily accomplished by action of microorganisms (SRC, 2003). Also, PAHs with 3 rings exist predominately in the vapor phase (WHO, 1998; ATSDR, 1995).

PAHs with 4 or more rings are generally resistant to biodegradation (SRC, 2003). PAHs with 4 rings can exist in both vapor and particulate phase and those with 5 or more rings exist predominately in the particulate phase (WHO, 1998; ATSDR, 1995); therefore volatilization of high molecular weight PAHs is not expected to be an important fate process. PAHs are not expected to volatilize from dry soil surfaces (SRC, 2003). Bioaccumulation by aquatic organisms is also greater for higher molecular weight PAHs than for lower molecular weight PAHs (ATSDR, 1995).

Summary of Risk from Cadmium, Lead, Chromium, and PAH Compounds in Stormwater Associated with WSDOT projects.

Stormwater associated with highway runoff may contain low levels of cadmium, lead, chromium, and PAH compounds. Often, these compounds are below levels that can be detected with current analytical methods. In addition, these compounds are effectively filtered or settled out in stormwater BMPs prior to being discharged to nearby waterbodies. Based on the environmental chemistry and biological fate of these compounds in an aquatic system, exposure to ESA-listed species is discountable and insignificant.

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